Annual Project Summary

Shear Wave Velocity, Geology and Geotechnical Data of Earth Materials in the Central U.S. Urban Hazard Mapping Areas

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Technical Abstract

The proposed project is to collect shear wave velocity measurements of nonlithified geologic materials along with their lithologic descriptions and geotechnical properties for the cooperative earthquake hazard mapping in St. Louis Urban Hazard Mapping and the Tri-State (Evansville) Urban Hazard Mapping area of Indiana, Kentucky and Illinois. This will ultimately produce a region-specific relationship between lithologies and seismic wave velocities for use in production of soil profile type derivative maps. This is being performed by collecting existing shear wave velocity and corresponding lithologic and geotechnical information, measuring in situ shear wave velocities in materials and areas where no or few values exist, and collecting lithologic and geotechnical data at new shear wave velocity sites. These information are being entered into an electronic database.

NON-TECHNICAL SUMMARY

The Central U.S. Earthquake Consortium (CUSEC) State Geologists are gathering information on the local geologic and material properties of the soils in the cooperative earthquake hazard mapping areas of St. Louis Urban Hazard Mapping and the Tri-State (Evansville) Urban Hazard Mapping area of Indiana, Kentucky and Illinois. The information gathered will allow production of geologic maps of the materials resting on the bedrock of these areas at a scale of 1:24,000 or 1 inch = 2,000 feet. The geologic map, along with measurements of the soil's properties, will be used to classify the various soils as to how much they would amplify earthquake ground motions. The amplification maps can be used in the Federal Emergency Management Agency's earthquake loss estimation program (HAZUS) to better estimate the amount of damages a community may expect from various earthquakes.

Investigations undertaken

COSMOS Database Workshop

The CUSEC State Geologists attended a workshop in Memphis, Tennessee on the Consortium of Strong Motion Observations Stations (COSMOS) geotechnical virtual database. This workshop was sponsored by the U.S. Geological Survey as a more detailed introduction to this distributed database structure. This distributed database has been assembled in Southern California with various California participants to present their available data through one portal site. This type of distributed database is being proposed for the Urban Hazard Mapping areas of the greater St. Louis, Missouri and Evansville, Indiana areas. Instructors were from University of Southern California, California Department of Transportation and the U.S. Geological Survey - Menlo Park. The workshop presented the details on the system and present up coming changes through the adoption of the system by international communities.

Missouri Geological Survey

The Missouri Geological Survey has been compiling existing geotechnical boring data for use in the St. Louis Area Earthquake Hazard Mapping Project. Records from 155 borehole logs have been entered into a Microsoft Access database to map potential earthquake seismic liquefaction and amplification hazards in the St. Louis, Missouri area. Of these borings, 127 have mapped locations thus far (see Figure 1). Figure 2 shows a more detailed borings location map for several project sites. The boring records have been compiled from 20 different environmental project site reports. All logs and associated map or table information in the reports will also be preserved in Acrobat *.pdf file format. Environmental site reports primarily contain soil material data, geochemical analysis results of soils, and some groundwater and bedrock information (Table 1).

These boring records compliment the current Missouri Geological Survey effort to obtain and compile data from the St. Louis Metropolitan Sewer District, the Missouri Department of Transportation and the US Army Corp of Engineers. Both data sets will be compiled into the same series of database tables, and in addition to being used to map earthquake hazards will be made available for public use.

Table 1: Summary of Data Types

FIELD VALUES	TOTAL
Sites or Structures	20
Number of Borings	155
Material Description Entries	1035
SPT N60 Values	682
Pocket Penetrometer	89
Torvane Shear	1
Liquid Limits	11

Plasticity Index	11
Weight Water Percent	14
ASTM Soil Class. Entries	647
Water Level Measurements	69
Specific Borehole Locations	127
Sources Scanned to .PDF Format	15

Kentucky Geological Survey

The University of Kentucky researchers have been acquiring seismic refraction/reflection and downhole data for characterizing the shear-wave velocity models of the soil/sediment overburden in the central United States for more than a decade. The dataset includes densely spaced measurements for urban microzonation studies and coarsely spaced measurements for regional assessments; however, the 500+ measurements and their derivative products often do not exist in an organized electronic form, limiting its accessibility for use by other researchers. In order to make these data more accessible, the objective of this project is to construct a database using the ArcGIS 8.3 software. The data will exist in a format that can later be integrated into a regional or national database that serves a wide array of users. The shear-wave velocities collected at locations throughout the upper Mississippi embayment and lower Wabash Valley, as well as the adjacent regions are archived with corresponding x, y, and z- coordinate information, impedance boundary elevations, available geotechnical index properties, as well as the velocities. The database design includes flexibility to also allow comprehensive Kentucky Seismic and Strong Motion Network data input (e.g., recorded ground motion values/time histories, weak motion waveform data, etc.) from nearby stations. Finally, the database will be migrated to the Kentucky Geological Survey (KGS) server and made available on the web.

Significant progress has been made on this project. The structure of the database has been set and most of the input data has been keyed in. The database will be completed in the Spring 2006 and a MS thesis will be developed and defended in the Spring 2006. The database will be used to re-evaluate the soil amplification maps for Western Kentucky.

Other related works performed by KGS include 1) editing of the CUSEC-SG promotional material; 2) designing a pamphlet to be used as a free handout; and 3) incorporating COSMOS database structure.

Indiana Geological Survey

The Indiana Geological Survey provided partial support for a student, from Purdue University, to enter geotechnical data from early work in the Evansville, Indiana area. The geotechnical borehole information was collected throughout the city and county when downhole shear wave velocity measurements were performed. The data was

entered using the gINT commercial software which places the data into a Microsoft Access database. Sixty-one project sites had some information entered from 368 borehole logs.

Illinois State Geological Survey

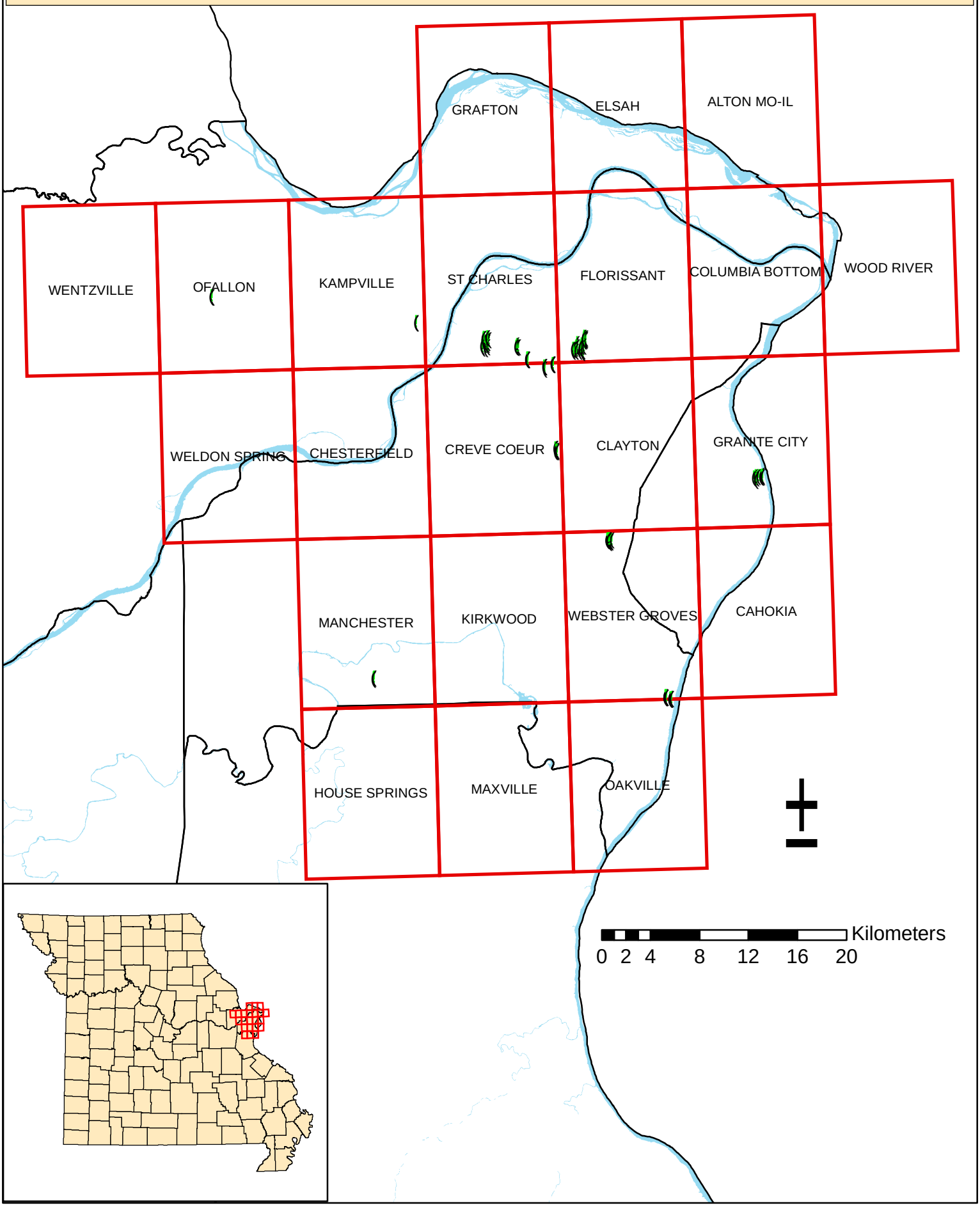
The Illinois State Geological Survey (ISGS) has gathered many more geotechnical borehole descriptions along the Mississippi River from the Illinois Department of Transportation in the St. Louis Urban Hazard Mapping area. The data is being placed into an Engineering Geology Database. The Survey has also coordinated with the University of Missouri – Rolla staff in assisting to pick locations in Illinois for their MASW shear wave velocity measurements. Some of their measurement sites are also sites where the ISGS has performed downhole shear wave velocity measurements within cased boreholes. This has allowed comparison between these two techniques at the same site (Figure 3 & 4). This site is in the America Bottom in the St. Louis Urban Hazard Mapping area where there is about 100 feet of sand with some gravel resting over the Mississippian limestone. The ISGS has coordinated with the U.S. Geological Survey's Earth Hazard Program staff to have their shear wave measurement techniques performed at the same site. This will allow for a comparison between 3 different shear wave velocity measurement techniques at a fairly simple geologic site. The comparison between the downhole and MASW methods show up to a 35% difference in values.

Summary

The Central U.S. Earthquake Consortium (CUSEC) State Geologists are gathering geological information in order that a geologic map of the materials resting on the bedrock at a scale of 1:24,000 or 1 inch = 2,000 feet can be produced in the cooperative earthquake hazard mapping areas of St. Louis Urban Hazard Mapping and the Tri-State (Evansville) Urban Hazard Mapping area of Indiana, Kentucky and Illinois. The geologic map, along with measurements of the soil's properties, will be used to classify the various soils as to how much they will amplify earthquake ground motions. The amplification maps can be used in the Federal Emergency Management Agency's earthquake loss estimation program (HAZUS) to better estimate the amount of damages a community may expect from various earthquakes. This work entails gathering all existing borehole information for stratigraphy and measuring shear wave velocity leading to the production of new maps of the "soils" and their thickness. The average shear wave velocity is calculated for the total column of "soil" and used to produce a map classifying the soils as to how much they will amplify earthquake ground motions.

Much of the geotechnical and shear wave velocity data are available in paper copy. Data is being added to electronic databases and we are working with USGS to form a consensus on the fields of a database for the two urban hazard mapping areas.

ST. LOUIS, MISSOURI AREA SURFICIAL MATERIALS DATABASE
FIGURE 1: BORING LOCATIONS



ST. LOUIS, MISSOURI AREA SURFICIAL MATERIALS DATABASE
FIGURE 2: BORING LOCATIONS

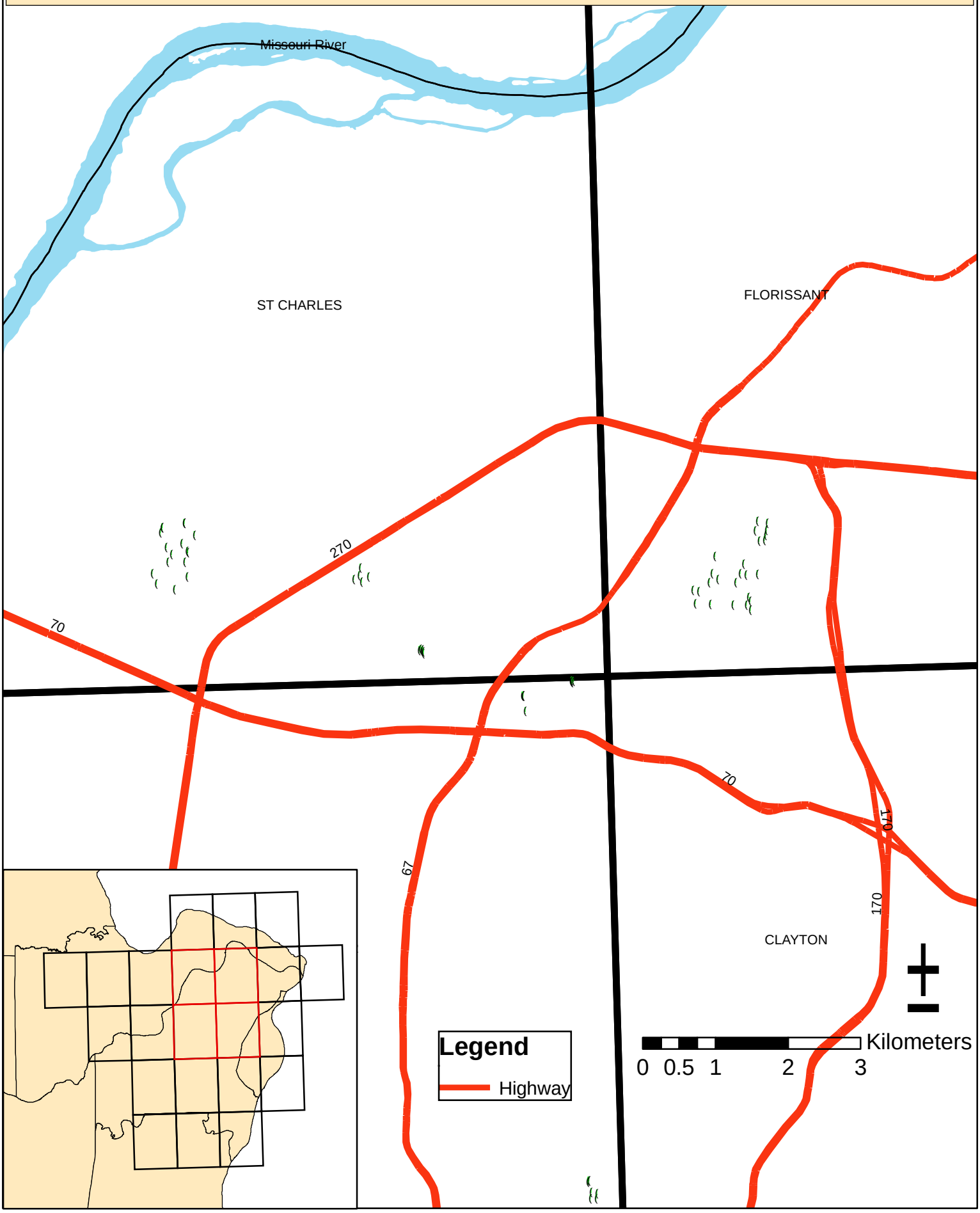


Figure 3. Comparison between shear wave velocity values measured by downhole and MASW methods for borehole MW-2.

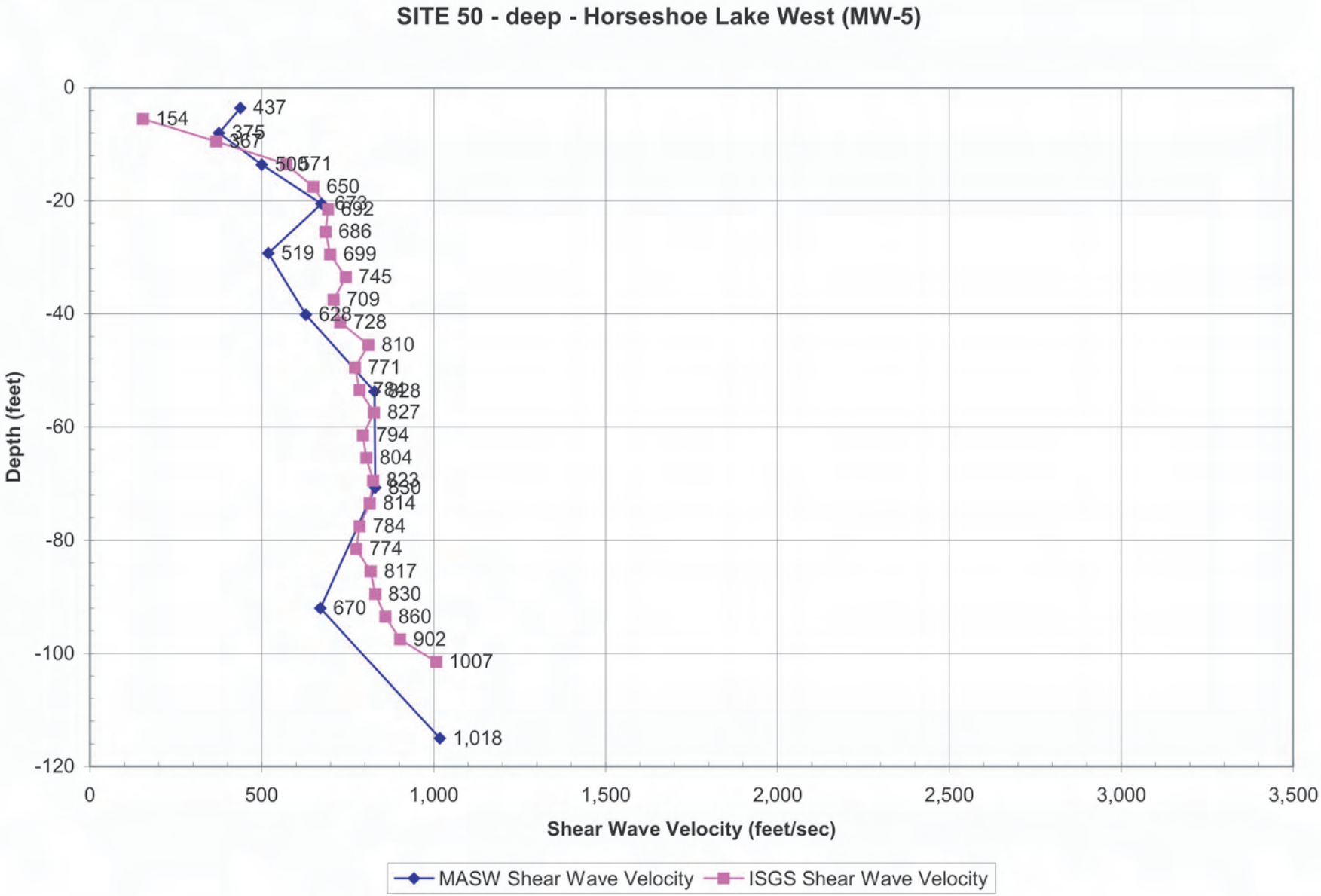


Figure 4. Comparison between shear wave velocity values measured by downhole and MASW methods for borehole MW-5.